1,000 mg calcium and 400 mg magnesium (Table 1, line 9 and 10) are still in solution after 202 days. Calcium alone (Table 1, lines 1 and 2) at 1,000 mg fell out of solution after 19 days.

In addition, Table 1 shows that a calcium magnesium composition of this invention with an added flavor system (Table 1, line 16) is still in solution after 198 days; these minerals dissolve and are stable in sports drinks such as Gatorade®, PowerAde® and AllSport® at the high concentrations of at least 500mg calcium and 200mg magnesium per 8 ounces of each of these drinks (Table 1, lines 26, 27 and 28).

Further, Table 1 shows that a calcium/magnesium composition of this invention has remained dissolved in Welch's 100% grape juice for 198 days, demonstrating the stability of the composition (Table I, line 29). Compositions of calcium alone were tried and they failed. The calcium fell out of solution within a short time.

It is completely unexpected that calcium and magnesium together make a more stable composition than calcium alone. The addition of other minerals to calcium, such as zinc, magnesium, and magnesium plus potassium and zinc, appears to enhance the stability and solubility of calcium.

TABLE 1

Elemental Mineral amounts are per 8 oz. water

#	Formula Example	Mixed with	Ca mg	Mg mg	K mg	Zn mg	pH	Still in Solution	Days
1	B	water	1,000				3.4	No	19
2	B	water	1,000				2.8	No	19
3	B	water	500				3.4	yes	202
4	B	water	500				2.8	yes	202
5	B	water	333				3.4	yes	202
6	B	water	333				2.9	yes	202
7	A1	water	2,000	800			3.4	no	40
8	A1	water	2,000	800			2.8	no	40
9	A1	water	1,000	400			3.4	yes	202
10	A1	water	1,000	400			2.8	yes	202
11	A1	water	500	200			3.4	yes	202
12	A1	water	500	200			2.8	yes	202
13	A1	water	4,000	1600			3.75	no	5
14	A1	water	1,000	400			3.75	yes	181
15	A1	water	500	200			3.75	yes	181
16	O	water	500	250			3.4	yes	198
17	L	water	2,000			30	3.75	yes	22
18	L	water	1,000			15	3.75	yes	22
19	L	water	500			7.5	3.75	yes	22
20	M	water	2,000	800	188	28	3.75	yes	22
21	M	water	1,000	400	94	14	3.75	yes	22
22	M	water	500	200	47	7	3.75	yes	22
23	G	water	800	3.75				yes	22
24	G	water	400	3.75				yes	22
25	G	water	200	3.75				yes	22
26	A1	Gatorade	500	200			4.08	yes	181
27	A1	PowerAde	500	200			4.09	yes	181
28	A1	AllSport	500	200			4.15	yes	181
29	F	Welch's Grape Juice	250	100			2.95	yes	198

Note for all samples:

1. All samples have been stored at 40-45°F
2. Note for all samples except 26-29:
   a. Potassium Benzoate was added at the rate of .1 % of total wt.
   b. Citric Acid was added to adjust to the target pH.

Table 2 shows the solubilization rates for compositions of this invention and similar commercial products. All samples were the equivalent of 3.4 g calcium in 8 ounces of deionized water at 68°F. The % of maximum solubility was measured at complete dissolution or at 7 minutes, whichever came first.

Table 2 and the graph of Fig. 2 show the speed of reconstitution at equivalent elemental concentrations of calcium for three of the products of this invention as compared to three products of the prior art. Formula Example B

(calcium lactate) ♦, Formula Example C (calcium magnesium lactate) □, and Formula Example D (calcium acetate lactate) ▲ were studied against the prior art Purac® Monohydrate (calcium lactate) *, Purac® Pentahydrate (calcium lactate) X and Gluconocal© (calcium gluconate lactate) •. Solubility was significantly higher with the products of this invention than each of the three prior art products. Fig. 2 shows this graphically. It is noted that 400 mg of freeze dried Formula B can be reconstituted in 8 oz. of water in 3 min. - a rate much faster for such a large amount of elemental calcium than possible with the prior art.

TABLE 2

	Dissolution Rates as % of Maximum Solubility					
Elapsed Time [mm:ss.s]	Formula Example B	Formula Example C	Formula Example D	Purac® Penta-hydrate	Purac® Mono-hydrate	Gluconal®
	Calcium Lactate	Calcium Magnesium Lactate	Calcium Acetate Lactate	Calcium Lactate	Calcium Lactate	Calcium Gluconate Lactate
00:00.0	0%	0%	0%	0%	0%	0%
00:05.4	22%	26%	9%	21%	9%	10%
00:10.7	43%	56%	23%	38%	15%	20%
00:16.1	50%	70%	32%	58%	21%	30%
00:21.5	58%	74%	41%	60%	22%	50%
00:26.9	67%	79%	49%	65%	28%	55%
00:32.2	69%	83%	62%	68%	29%	45%
00:37.6	77%	85%	92%	70%	29%	58%
00:43.0	80%	88%	94%	70%	31%	63%
00:48.4	83%	90%	98%	71%	33%	66%
00:53.7	87%	91%	99%	72%	33%	71%
00:59.1	91%	93%	100%	72%	34%	71%
01:04.5	92%	95%		73%	35%	77%
01:09.9	93%	95%		73%	36%	77%
01:15.3	96%	96%		73%	37%	80%
01:20.6	97%	96%		74%	40%	83%
101:26.0	98%	96%		74%	41%	86%
01:36.7	99%	97%		75%	43%	85%
01:47.5	99%	98%		75%	45%	85%
01:58.2	100%	98%		75%	50%	86%
02:09.0		98%		76%	51%	88%
03:30.5		100%		76%	55%	94%
03:00.0				76%	60%	98%
04:00.0				77%	67%	99%
05:00.0				78%	75%	99%
06:00.0				78%	75%	99%
07:00.0				78%*	79%**	99%***

*After 1 hour, 31 minutes—80%
**After 59 minutes—85.2%
***After 8 minutes, 41 seconds—100%

Table 3 shows reconstitution times of calcium/magnesium lactate products mixed as described herein. These minerals were used in the ratio of calcium: magnesium of 5:2. The RDI for calcium is 1000 mg, while the RDI for magnesium is 400 mg. The starting formula for one of the products contained 30% solids at the 5:2 ratio dissolved in water (A1), while the other formula began with 50% solids at the 5:2 ratio (A2). Even though the procedures start out with different quantities of minerals, albeit in the same ratios, the concentrations of the minerals in the final powder product are the same in A1 and A2. These concentrations are 100 mg calcium/gm product and 40 mg magnesium/gm product.

The first two samples were freeze dried, the third sample was spray dried and the fourth sample was tray dried. The table shows time for reconstitution of the dried powders, producing calcium and magnesium concentrations in water at various percentages of the RDI for these minerals: 25% (2.5 grams of the product), 33% (3.3 grams of the product), 50% (5 grams of the product), 100% (10 grams of the product), 200% (20 grams of the product), 300% (30 grams of the product) and 400% (40 grams of the product). In all cases the time for reconstitution of the powder products was calculated from the time the powder was put into the beaker (400 ml Pyrex, filled to 8oz) until the water was clear and at least 95% of the powder was in solution. In the event that 5% was not dissolved during the first measured period of time, such as with some of the high concentration tray dried or freeze dried formulas, this remaining 5% dissolved within the next few minutes without any additional stirring. In each case tap water was used for reconstitution. The magnetic stirrer (Barnstead Thermolyne Model #S46415) was set to "8". Occasionally, a spoon was used to assist the solubilization of the powder.

The reconstitution times vary with the temperature of the water and the concentration of the minerals. With large quantities of powder it took longer for the material to be added to the beaker than with smaller quantities. Temperatures at which reconstitution times were tested were 190-195°F, 130-140°F, 70-75°F (ambient temperature) and 40-45°F. Times on the table are presented in minutes:seconds format.

TABLE 3

2.50 grams of powder (25% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:06	00:13	00:21	00:33
A2 freeze dried	00:08	00:25	00:50	01:00
A2 spray dried	00:06	00:15	00:28	00:58
A2 tray dried	00:05	00:25	01:20	03:16

3.33 grams of powder (33% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:06	00:30	00:45	01:10
A2 freeze dried	00:12	00:34	01:05	01:16
A2 spray dried	00:07	00:22	00:31	01:30
A2 tray dried	00:05	00:30	01:30	04:54

5.00 grams of powder (50% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:08	00:25	00:35	01:22
A2 freeze dried	00:08	00:20	01:10	01:50
A2 spray dried	00:05	00:22	00:36	00:56
A2 tray dried	00:05	00:30	01:33	05:54

10.00 grams of powder (100% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:08	00:30	01:00	03:17
A2 freeze dried	00:12	00:50	02:50	04:20
A2 spray dried	00:08	00:20	00:36	01:39
A2 tray dried	00:07	00:40	02:50	11:25

20.00 grams of powder (200% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:22	00:50	01:00	06:10
A2 freeze dried	00:26	01:50	03:00	*
A2 spray dried	00:10	00:30	03:55	04:23
A2 tray dried	00:13	00:58	03:45	12:48

*Not totally soluble

30.00 grams of powder (300% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:21	**	**	**
A2 freeze dried	00:20	**	**	**
A2 spray dried	00:21	**	**	**
A2 tray dried	00:21	**	**	**

**Not tested

40.00 grams of powder (400% RDI) reconstituted in water

Formula and Drying Method	Min:Sec to Reconstitute in Water at Noted Temperatures			
	190-195°F	130-140°F	70-75°F	40-45°F
Al freeze dried	00:30	**	**	**
A2 freeze dried	00:32	**	**	**
A2 spray dried	00:35	**	**	**
A2 tray dried	00:30	**	**	**

**Not tested

It is clear when Table 1, Table 2 and Table 3 are viewed together that the products of this invention are highly soluble and highly stable at high concentrations. It is also clear that the calcium/magnesium, calcium/zinc and calcium/magnesium/potassium/zinc products of this invention are more highly soluble and more stable than a calcium product alone.

SENSORY

The products of this invention, both powder and reconstituted, have an improved taste, smell and texture over the starting ingredients prior to any processing. This is an unexpected result. The sensory properties of the solution of Step 4 (Figure 1) are improved over those of Step 1, and the

sensory properties upon reconstitution in Steps 7F and 9 are further improved over those of Step 4. This has been found regardless of the particular method of drying.

PHYSICAL CHARACTERISTICS

a) Amorphous structure

When a solid compound is formed from solution by slowly evaporating its water, the atoms of the compound arrange themselves into an ordered crystal structure, forming strong bonds among the solid's cations and anions. However, when a solid forms rapidly, the atoms of the compound are unable to form an ordered crystal structure, and the bonds among the solid's ions are weaker. This non-crystalline solid is also known as an amorphous solid.

In the present invention, a regular crystal structure does not exist. Instead, the product is an amorphous solid. Figure 3 shows X-ray diffraction patterns for some of the compounds of this invention. These indicate that the present compounds are less crystalline (i.e., more amorphous) than the compounds in the prior art. Figure 4 shows SEM pictures of some of the products, in which the amorphous structure can be seen.

The product is apparently a sequestrant, i.e., the result of sequestration, which allows high concentrations to be solubilized without precipitating out of solution. "Sequestration" can be defined as the combining of metallic ions with a suitable reagent into a stable, soluble complex in order to prevent the ions from combining with a substance with which they would otherwise have formed an insoluble precipitate, from causing interference in a particular reaction, or from acting as undesirable catalysts.

b) Lower water content

For compounds to dissolve in water, the bonds between the cations (e.g., calcium) and the anions (e.g., lactate) must be broken. Energy is required, in the form of heat, to break these bonds. However, once these bonds are broken, consuming heat, new bonds form between the water and the dissolved ions, thus releasing some energy, also in the form of heat. More energy is produced than is consumed in the reaction. This released energy is called the heat of hydration.